Chapter 6. Demersal Fishes and Megabenthic Invertebrates

Introduction

Demersal (bottom dwelling) fishes and relatively large (megabenthic), mobile invertebrates are collected and analyzed for the Point Loma Ocean Outfall (PLOO) monitoring program to evaluate possible effects of wastewater discharge on their communities. These fishes and invertebrates are conspicuous members of continental shelf habitats and are therefore important to the ecology of the southern California coastal shelf, serving vital functions in wide ranging capacities. Because such organisms live in close proximity to the seafloor, they can be impacted by changes in sediments affected by both point and non-point sources (e.g., discharges from ocean outfalls and storm drains, surface runoff from watersheds, outflows from rivers and bays, disposal of dredge materials; see Chapter 4). For these reasons, their assessment has become an important focus of ocean monitoring programs throughout the world, but especially in the Southern California Bight (SCB) where they have been sampled extensively on the mainland shelf (Cross and Allen 1993).

Demersal fishes and megabenthic invertebrate communities are inherently variable and are influenced by many factors. Therefore, distinguishing changes in these communities caused by anthropogenic influences such as the PLOO wastewater discharge from other, more natural, sources is an important aspect of the ocean monitoring program. Natural factors that may affect these organisms include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperatures associated with large scale oceanographic events such as El Niño/La Niña oscillations (Karinen et al. 1985). These factors can affect migration patterns of adult fishes or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect species diversity and abundance of both fishes and invertebrates may also be due to the mobile nature of many species (e.g., fish schools, urchin aggregations).

This chapter presents analyses and interpretations of the trawl survey data collected during 2010, as well as a long-term assessment of these communities from 1991 through 2010. The primary goals are to: (1) identify possible effects of wastewater discharge on demersal fishes and megabenthic invertebrates, (2) determine the presence or absence of biological impacts near the discharge site, and (3) identify spatial or temporal trends in demersal community structure in the region.

Materials and Methods

Field Sampling

Trawl surveys were conducted at six fixed monitoring sites in the Point Loma region during January and July 2010 (Figure 6.1). The six trawl stations, designated SD7, SD8, SD10, SD12, SD13 and SD14, are located along the 100-m depth contour, and encompass an area ranging from ~8 km north to 9 km south of the PLOO. A single trawl was performed at each station during each survey using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.0 knots along a predetermined heading.

The total catch from each trawl was brought onboard ship for sorting and inspection. All fishes and invertebrates captured were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. For fishes, the total number of individuals and total biomass (kg, wet weight) were recorded for each species. Additionally, each individual fish was inspected for physical anomalies or indicators of disease (e.g., tumors, fin erosion, discoloration) as well as the presence of external parasites, and

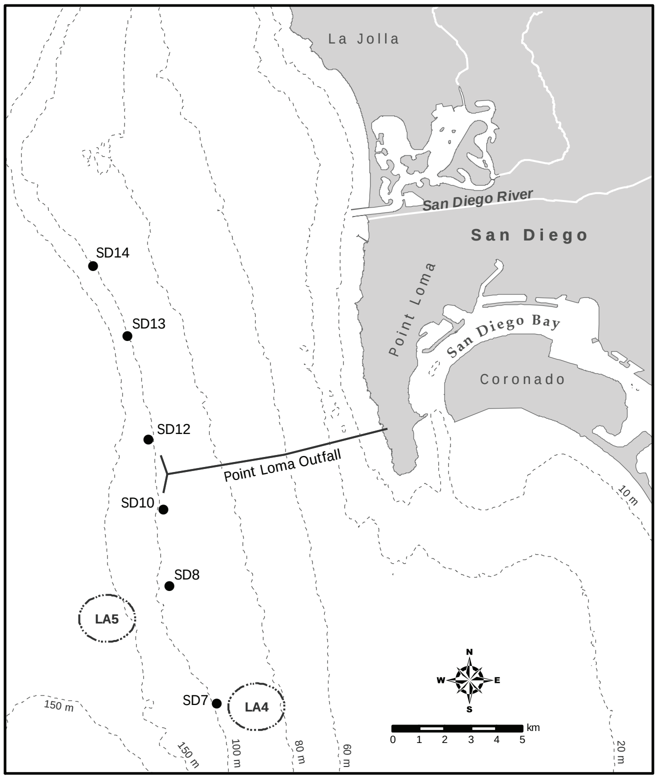

Figure 6.1
Otter trawl station locations, Point Loma Ocean Outfall Monitoring Program.

then measured to the nearest centimeter size class (standard lengths). For invertebrates, the total number of individuals was recorded per species.

Data Analyses

Populations of each fish and invertebrate species were summarized as percent abundance (number of individuals of a single species/total number of individuals of all species), frequency of occurrence (the percentage of stations at which a species was collected), mean abundance per haul (number of individuals of a single species/total number sites sampled), and mean abundance per occurrence (number of individuals of a single species/number of sites at which the species was collected). In addition, species richness (number of taxa), total abundance (number of individuals), and the Shannon diversity index (H') were calculated for both fishes and macroinvertebrates for each station, while total biomass was calculated for just fishes for each station. For historical comparisons the data were grouped as "nearfield" stations (SD10, SD12), "south farfield" stations (SD7, SD8), and "north farfield" stations (SD13, SD14). The two nearfield stations were those located closest to the outfall (i.e., within 1000 m of the north or south diffuser legs).

Multivariate analysis to examine differences of demersal fish communities in the region was performed with data collected from 1991 through 2010. However, to eliminate noise due to natural seasonal variation in populations, data analyzed were restricted to July surveys. PRIMER software was used to test for spatio-temporal differences among fish assemblages from nearfield and farfield locations (Clarke 1993, Warwick 1993, Clarke and Gorley 2006). Prior to analysis, fish abundance data were square root transformed to lessen the influence of prevalent species and increase the weight of rare species, and a Bray-Curtis similarity matrix was created from transformed data with nearfield/farfield locations and year provided as factors. Because species composition was sparse at some stations, a "dummy" species with an abundance value of 1 was added to all samples prior to computing similarities (Clarke and Gorley 2006). A two-way crossed analysis of similarity (ANOSIM; A=nearfield/farfield location, B=year; maximum number of permutations=9999) was conducted to determine whether fish abundances differed between nearfield and farfield locations or years. When significant differences were detected, square-root transformed data were averaged by factor (i.e., nearfield/farfield location, year) and a similarity percentages (SIMPER) analysis was used to identify which fish species accounted for the majority of differences observed. Non-metric multidimensional scaling (nMDS) ordinations and cluster dendrograms were created to visually depict the relationship of averaged data by factor (i.e., nearfield/farfield area, year). Cluster dendrograms were generated using hierarchical agglomerative clustering with group-average linking.

To visually depict relationships among individual sites by year (rather than areas by year) based on fish community composition, a second nMDS ordination and dendrogram were produced. Similarity profile (SIMPROF) analysis was used

Table 6.1

Demersal fish species collected in 12 trawls in the PLOO region during 2010. PA = percent abundance; FO = frequency of occurrence; MAO = mean abundance per occurrence; MAH = mean abundance per haul.

Species	PA	FO	MAO	MAH	Species	PA	FO	MAO	MAH
Pacific sanddab	42	100	191	191	California scorpionfish	< 1	50	4	2
California lizardfish	18	100	80	80	Bigmouth sole	< 1	83	2	1
Yellowchin sculpin	17	75	100	75	California skate	< 1	58	2	1
Longspine combfish	6	100	29	29	Slender sole	< 1	25	5	1
Dover sole	4	75	24	18	Longfin sanddab	< 1	17	7	1
Halfbanded rockfish	3	100	12	12	Hornyhead turbot	< 1	58	2	1
Stripetail rockfish	2	75	14	10	Blackbelly eelpout	< 1	25	3	1
Shortspine combfish	1	92	7	6	Spotted cuskeel	< 1	25	1	< 1
English sole	1	83	7	6	Spotfin sculpin	< 1	8	3	< 1
Plainfin midshipman	1	100	6	6	Blacktip poacher	< 1	17	1	< 1
Roughback sculpin	1	58	7	4	Greenspotted rockfish	< 1	8	2	< 1
Pink seaperch	1	100	3	3	Longnose skate	< 1	8	1	< 1
California tonguefish	1	58	5	3	Rosethorn rockfish	< 1	8	1	< 1
Greenstriped rockfish	< 1	75	3	2					

to confirm non-random structure of the resultant cluster dendrogram (Clarke et al. 2008), and major clusters supported by SIMPROF were subjectively retained for illustrative purposes based on the 0.1 level of significance provided by the SIMPROF analysis. SIMPER analysis was subsequently used to identify which species primarily account for observed differences between cluster groups, as well as to identify species typical of each group.

Results

Demersal Fish Community Parameters

Twenty-seven species of fish were collected in the area surrounding the PLOO in 2010 (Table 6.1, Appendix E.1). The total catch for the year was 5450 individuals, representing an average of ~454 fish per trawl. As in previous years, Pacific sanddabs were dominant, occurring in every haul and accounting for 42% of the total number of fishes collected. California lizardfish, halfbanded rockfish, longspine combfish, plainfin midshipman, and pink seaperch were also collected in every haul, but in much lower numbers. Other species collected frequently (≥75% of the trawls) included yellowchin sculpin, Dover sole, stripetail rockfish, shortspine combfish, English sole, greenstriped rockfish, and bigmouth sole. Pacific sanddabs, yellowchin sculpin, and California lizardfish averaged 191, 100, and 80 individuals per trawl, respectively, while all other species averaged 29 individuals or less per survey and contributed < 6% to the total overall catch. Although the majority of species captured in the Point Loma region tended to be relatively small fishes with an average length ≤20 cm, large individuals of Dover sole, English sole, California scorpionfish and Pacific sanddab that ranged from 22 to 25 cm in length were documented (Appendix E.1).

Species richness of fish from individual hauls ranged from 13 to 19 during 2010, and the corresponding diversity (H') values were all ≤2.0 (Table 6.2). Total abundance of all fish species combined ranged from 337 to 579 fishes per haul. Variation among hauls was driven primarily by differences in the number of yellowchin sculpin, Pacific sanddab, and California lizardfish documented at each station (Appendix E.2). This differed from 2009 where Pacific sanddabs were the only species responsible for the majority of differences observed. In fact, during 2010 surveys, the abundance of California lizardfish was the largest recorded since January 1992 (> 460 individuals caught per sampling period

Table 6.2

Summary of demersal fish community parameters for PLOO trawl stations sampled during 2010. Data are included for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight); SD = standard deviation.

Station	January	July
Species Richness		
SD7	15	13
SD8	17	14
SD10	14	19
SD12	16	15
SD13	17	16
SD14	16	18
Survey Mean	16	16
Survey SD	1	2
Abundance		
SD7	419	383
SD8	337	494
SD10	567	419
SD12	471	524
SD13	387	579
SD14	482	388
Survey Mean	444	465
Survey SD	81	80
Diversity		
SD7	1.6	0.9
SD8	2.0	1.1
SD10	1.6	1.6
SD12	2.0	1.6
SD13	1.8	1.2
SD14	1.6	1.1
Survey Mean	1.8	1.3
Survey SD	0.2	0.3
Biomass		
SD7	5.2	4.7
SD8	6.9	4.4
SD10	9.0	9.9
SD12	9.6	10.6
SD13	7.8	7.0
SD14	7.9	6.9
Survey Mean	7.7	7.2
Survey SD	1.6	2.6

in 2010), while the abundance of yellowchin sculpin caught in January (870 individuals) was the largest total recorded since January 2003. Fish biomass ranged from 4.4 to 10.6 kg per haul, with higher values coincident with either greater numbers of fishes or the presence of large individual fish. For example, the maximum biomass recorded at any one station (i.e., SD12) reflects the combined weight of Pacific sanddab (1.6 kg), California lizardfish (2.9 kg), California skate (3.0 kg), and a mixture of other common species (4.7 kg) (Appendix E.3). Over the entire year, the combined maximum weight for common fish species collected within the PLOO region was 23.9 kg for Pacific sanddab, 13.8 kg for California lizardfish, 6.2 kg for California scorpionfish, 5.9 kg for Dover sole, 5.7 kg for California skate, and 6.0 kg for English sole.

Large fluctuations in populations of a few dominant species are the primary factors contributing to the high variation in fish community structure observed off Point Loma since 1991 (Figures 6.2, 6.3). For example, species richness values for individual trawls performed within the PLOO region since 1991 have ranged from 7 to 26 species, while total abundance of fishes per haul has varied from 44 to 2322 individuals/station/survey. Fluctuations in abundance have been greatest at nearfield and northern farfield stations, and generally reflect population differences of the most abundant species: Pacific sanddab, yellowchin sculpin, plainfin midshipman, longspine combfish, Dover sole, longfin sanddab, and halfbanded rockfish (Figure 6.3). Because temporal changes in dominant species are similar between nearfield and northern farfield stations, observed changes in fish populations do not appear to be associated with wastewater discharge.

Classification of Demersal Fish Assemblages

Two-way crossed ANOSIM revealed fish populations to differ among nearfield and farfield areas (Global $R = 0.368$, $p = 0.0001$) and year (Global $R = 0.611$, $p = 0.0001$). Individual pairwise tests found that fish populations at nearfield stations did not differ from either north or south farfield stations ($r = 0.171$ and 0.224, respectively), but that north and south farfield stations possessed fish populations that were significantly different ($r = 0.737$, $p = 0.0001$). Thus, in support of anecdotal

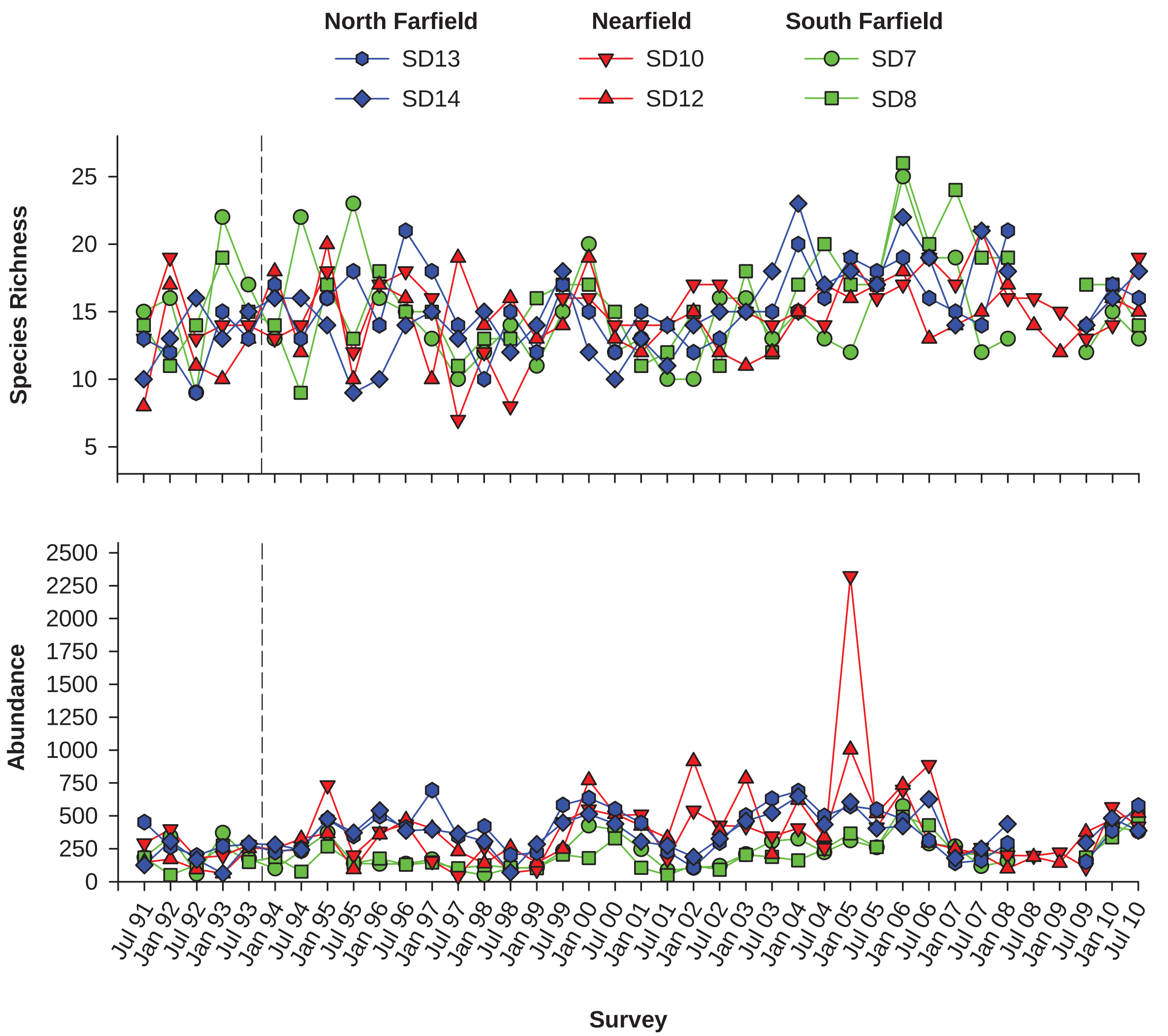

Figure 6.2

Species richness and abundance of demersal fishes collected at each PLOO trawl station between 1991 and 2010. Data are total number of species and total number of individuals per haul, respectively. Dashed line represents initiation of wastewater discharge. Only stations SD10 and SD12 were sampled during July 2008 and January 2009 due to a Bight'08 resource exchange.

observations made since 1991, a gradual gradient exists across the PLOO region that results in fish populations at northern sites being statistically distinct from fish populations at southern sites (Figure 6.1). SIMPER revealed abundances of six fish species whose abundances each contributed to ≥5% of differences observed between north farfield and south farfield stations: Pacific sanddab, stripetail rockfish, plainfin midshipman, halfbanded rockfish, Dover sole, and yellowchin sculpin (Appendix E.4). In all cases, abundances of these fish species were greater at north farfield sites than south farfield sites. nMDS graphically illustrates the annually-persistent gradient in fish populations that has been observed since 1991 among the three nearfield/farfield locations surveyed by depicting distinct clusters of north and south farfield sites commingling with the cloud of nearfield sites (Figure 6.4).

The two-way crossed ANOSIM also revealed 58% of pairwise comparisons among sites by year to

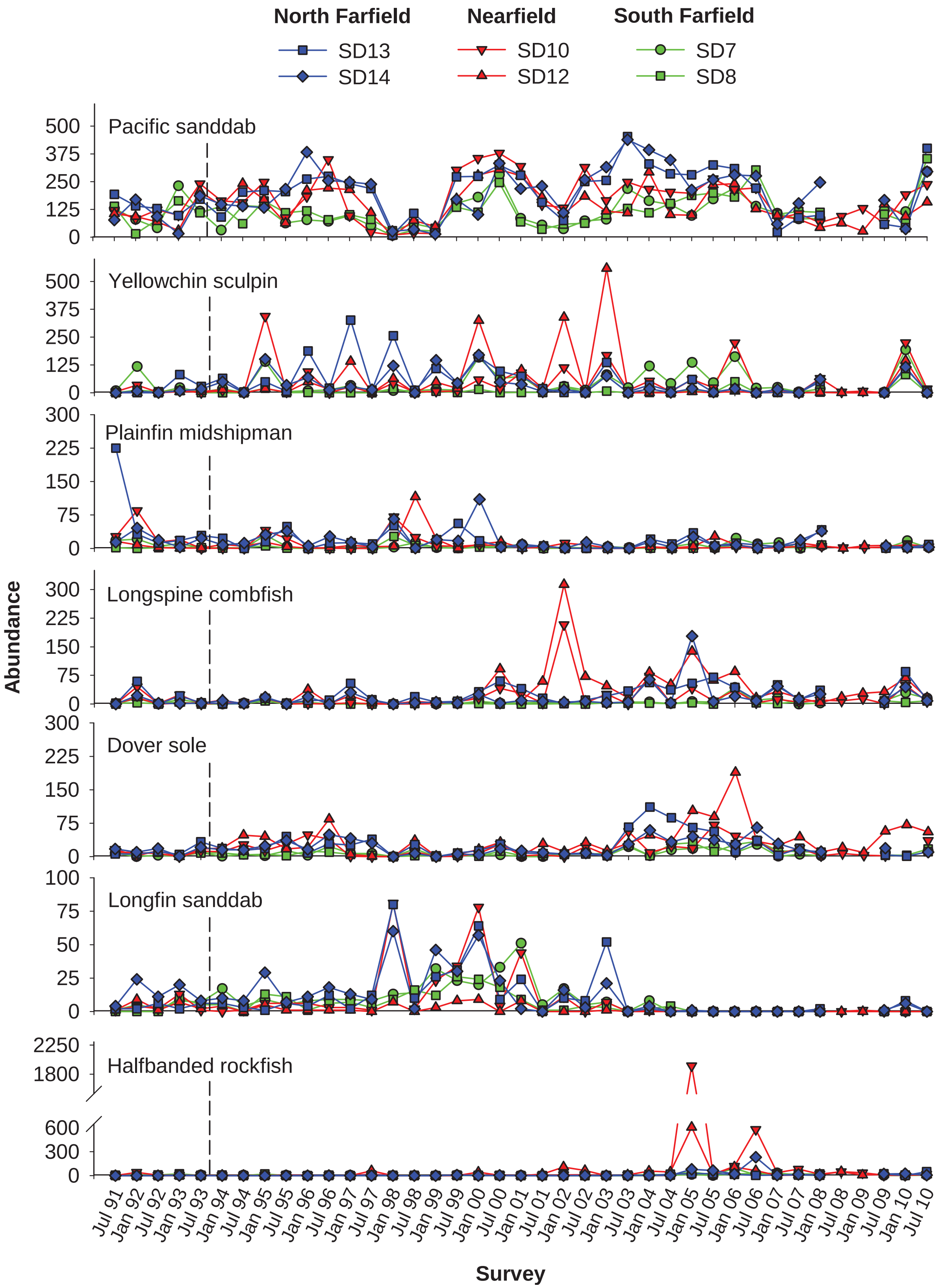

Figure 6.3

The seven most abundant fish species collected in the PLOO region from 1991 through 2010. Data are total number of individuals per haul. Dashed line represents initiation of wastewater discharge. Only stations SD10 and SD12 were sampled during July 2008 and January 2009 due to a Bight'08 resource exchange.

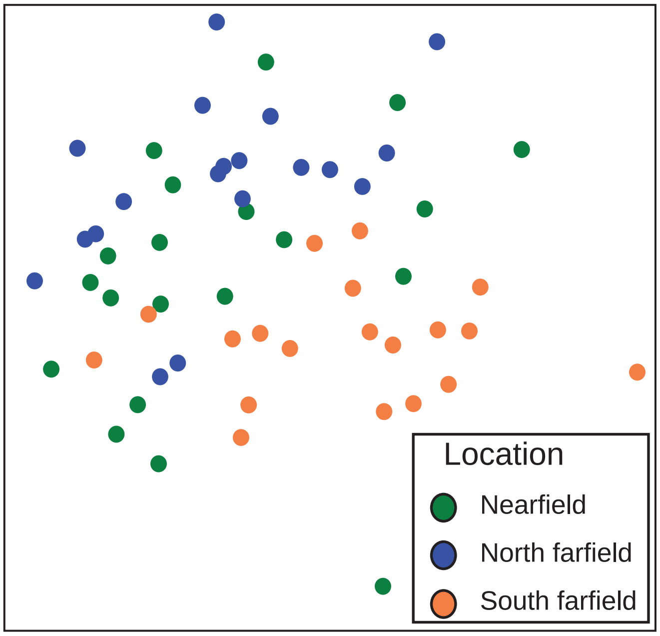

Figure 6.4
nMDS plot depicting relationships among PLOO locations (nearfield, north farfield, south farfield) based on demersal fish abundances for 1991–2010. Stress = 0.19.

be significant, indicating that fish communities differed not only among nearfield/farfield location (as discussed above), but also by survey year. A cluster dendrogram and nMDS ordination reveal that a change in fish populations occurred across the entire PLOO region between 2002 and 2003 (Figure 6.5), with data from 1991–2002 forming one supported cluster, and data from 2003–2010 forming a second supported cluster. Within the 2003–2010 cluster, data from 2008 segregate apart from other years. SIMPER revealed that abundances of five fish species each contributed to $\geq$4% of differences observed between the two major clades: longfin sanddab, halfbanded rockfish, California lizardfish, greenstriped rockfish, and bay goby (Appendix E.5). Of the fish species that accounted for 90% of observable differences between the two major clades, 60% exhibited higher abundances from 2002–2010 than from 1991–2002. Within the 2003–2010 clade, data collected from 2008 differ from other years in having no occurrences of stripetail rockfish, California lizardfish, California tonguefish, or hornyhead turbot. Because PLOO wastewater discharge began in 1993, the temporal shift in fish communities observed between 2002 and 2003 is likely driven by natural large-scale oceanographic processes (see Chapter 2) rather than PLOO discharge.

Ten main assemblages were interpreted from cluster analyses when fish abundance data were examined by site from 1991 through 2010 (cluster groups A–J; Figure 6.6). SIMPER results show that the demersal fish communities at all survey locations off Point Loma have been dominated by Pacific sanddabs for almost 20 years, with differences in the relative abundance of this or other common species discriminating between the different interpreted cluster groups (Table 6.3, Appendix E.6). In fact, SIMPER revealed that the mix of species occurring in many cluster-analysis defined groups was similar, and it is often differences in species abundance rather than species diversity that delimited each cluster group. For instance, group C possessed populations of squarespot and greenblotched rockfish that were 77 and 4 times higher than any other group, respectively. Additionally, group C possessed the only site during 20 years of surveys where vermilion rockfish were recorded. As another example, group D possessed populations of longfin sanddab and stripetail rockfish 4 and 10 times higher than any other group.

During 2010, fish assemblages at each station were similar to those reported from 2006 to 2009, with the exception of SD7 in 2007 (Figure 6.6). SIMPER found high abundances of Pacific sanddab, halfbanded rockfish, Dover sole, longspine combfish, and shortspine combfish to differentiate most 2006 through 2010 fish assemblages from assemblages reported from 1991 through 2005. No observable spatial or temporal patterns in fish community structure can be attributed to the outfall or the onset of wastewater discharge. Instead, most differences in local fish assemblages appear to be related to large-scale oceanographic events (e.g., El Niño conditions in 1998) or the unique characteristics of a specific station. For example, fish assemblages at the south farfield stations often grouped apart from the remaining trawl stations (as was also detected by ANOSIM analysis, above).

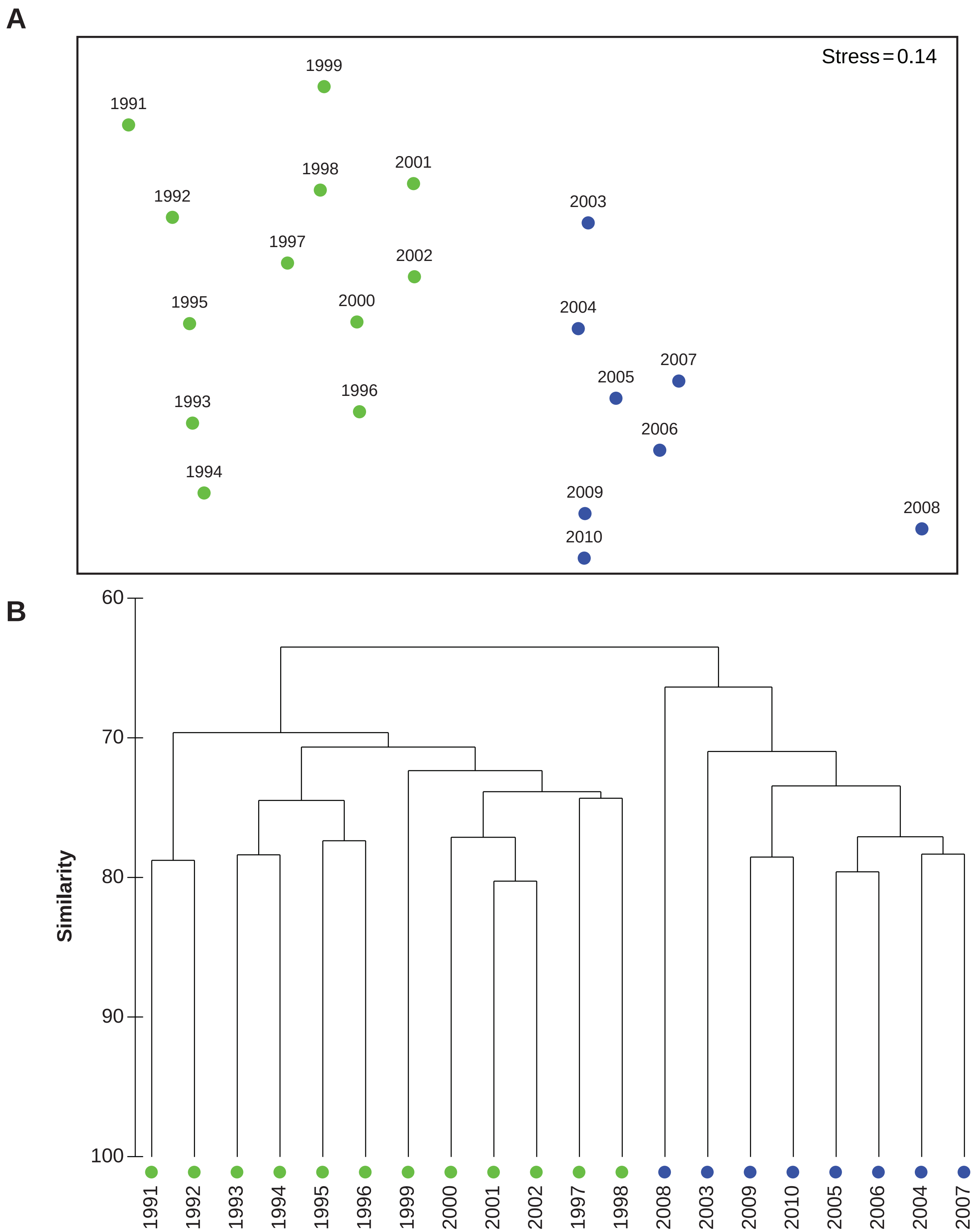

Figure 6.5

Results of classification analysis of demersal fish assemblages collected at PLOO stations by year (July surveys only). Data are presented as (A) nMDS and (B) cluster diagram depicting relationships among years based on averaged demersal fish population abundances found in the PLOO region between 1991 and 2010. Fish populations from 1991–2002 form one supported cluster, while fish populations from 2003–2010 form a second supported cluster.

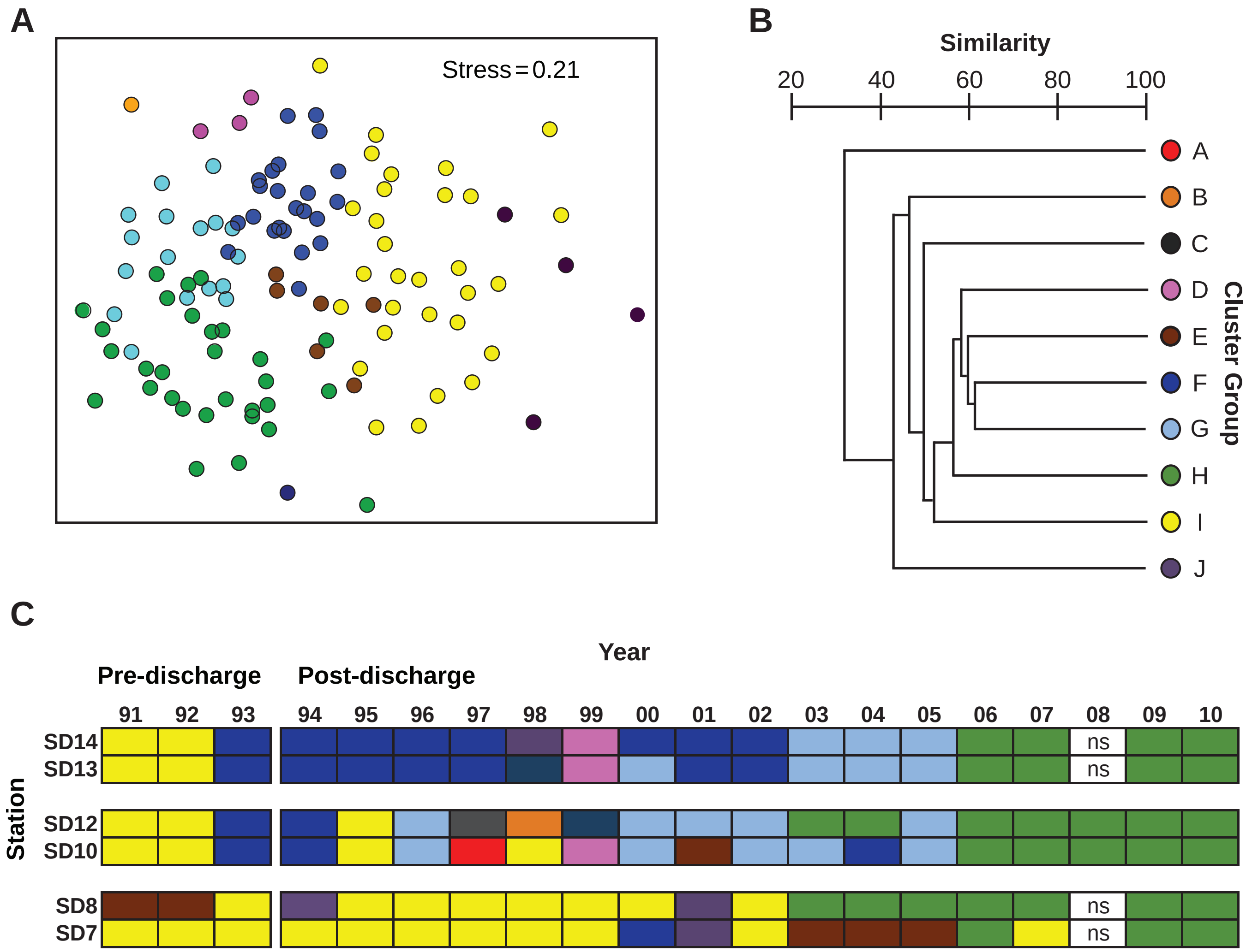

Figure 6.6

Results of classification analysis of demersal fish assemblages collected at PLOO stations SD7–SD14 between 1991 and 2010 (July surveys only). Data are presented as (A) nMDS ordination, (B) a dendrogram of major cluster groups, and (C) a matrix showing distribution of cluster groups over time with stations grouped as "North Farfield" (SD13, SD14), "Nearfield" (SD10, SD12), and "South Farfield" (SD7, SD8); ns = not sampled.

Physical Abnormalities and Parasitism

Demersal fish populations appeared healthy in the PLOO region during 2010. There were no incidences of fin rot, discoloration, skin lesions, tumors or any other indicators of disease among fishes collected during the year. Evidence of parasitism was also very low with only 0.6% of trawl-caught fishes being infested. Pacific sanddabs appeared to be the species most susceptible to parasitism with ~1.4% of the population infected by the copepod *Phrixocephalus cincinnatus*. Overall, fishes from station SD10 exhibited the highest degree of parasitism, with 17 cases reported. Additionally, three individuals of the cymothoid isopod, *Elthusa vulgaris*, were identified as part of the trawl catches over the course of the year (Appendix E.7). Since cymothoids often become detached from their hosts during retrieval and sorting of the trawl catch, it is unknown which fishes were actually parasitized by these isopods. However, *E. vulgaris* is known to be especially common on sanddabs and California lizardfish in southern California waters, where rates of infestation can reach 3% and 80%, respectively (Brusca 1978, 1981).

Table 6.3
Description of cluster groups A–J defined in Figure 6.6. Data include number of hauls, mean species richness, mean total abundance, and mean abundance of the five most abundant species for each station group. Bold values indicate species that were considered among the most “characteristic” of that group according to SIMPER analysis (i.e., greatest percentage contribution to within-group similarity).

	Cluster Groups									
	A	B	C	D	E	F	G	H	I	J
Number of Hauls	1	1	1	3	6	23	17	30	30	4
Mean Species Richness	7	16	19	17	14	14	16	16	13	11
Mean Abundance	44	261	231	495	213	307	467	321	162	71
Species	**Mean Abundance**									
Pacific sanddab	23.0	75.0	110.0	**248.3**	**150.2**	**215.2**	**300.9**	**169.3**	**97.4**	**46.8**
Halfbanded rockfish	16.0		60.0	6.7	2.7	1.2	15.5	**46.3**	1.8	
Longfin sanddab	1.0			**31.7**		7.8	1.0	0.2	6.8	2.0
Pink seaperch	1.0	4.0	1.0	4.0	1.8	5.6	4.4	3.7	0.9	1.0
Spotfin sculpin	1.0						0.5	1.5	2.1	0.8
Gulf sanddab	1.0	5.0		9.7	0.2	0.2	0.1		0.2	0.5
Greenspotted rockfish	1.0		1.0	0.3		0.7	0.3	0.1	0.4	
Stripetail rockfish		1.0	5.0	**102.0**	0.2	10.4	5.8	3.9	8.3	3.8
Dover sole		36.0	1.0	**5.0**	**14.5**	**22.7**	**48.1**	**24.3**	**10.0**	3.3
Yellowchin sculpin				**31.0**	20.0	14.7	16.2	2.2	3.5	2.5
Longspine combfish		7.0	2.0	**5.0**	**2.7**	5.0	32.5	**10.7**	0.7	2.3
Greenblotched rockfish			8.0	1.3	1.8	0.9	1.4	0.3	0.7	1.0
Plainfin midshipman		116.0	4.0	26.0	**2.3**	10.7	5.7	4.1	**14.6**	0.8
California lizardfish				6.0				22.0	0.5	0.5
Squarespot rockfish			23.0					0.1	0.1	0.3
Shortspine combfish			3.0		5.2	0.5	3.6	**10.2**	2.1	
Vermilion rockfish			6.0							

Invertebrate Community

A total of 19,562 megabenthic invertebrates (~1630 per trawl) representing 43 taxa were collected during 2010 (Table 6.4, Appendix E.7). As in previous years, the sea urchin *Lytechinus pictus* was the most abundant and most frequently captured species, occurring in all trawls and accounting for 91% of the total invertebrate abundance. The brittle star *Ophiura luetkenii* was also collected in every haul, but in much lower numbers. Other common species that occurred in 50% or more of the hauls included the sea pen *Acanthoptilum* sp, the sea slug *Pleurobranchaea californica*, the sea cucumber *Parastichopus californicus*, the sea stars *Astropecten verrilli* and *Luidia foliolata*, and the octopus *Octopus rubescens*.

Megabenthic invertebrate community structure varied among stations and between surveys during the year (Table 6.5). Species richness ranged from 7 to 17 species per haul, diversity (H') values ranged from 0.1 to 1.1 per haul, and total abundance ranged from 719 to 3447 individuals per haul. Patterns in total invertebrate abundance mirrored variation in populations of the sea urchin *L. pictus* because of its overwhelming dominance at all stations (with the exception on SD14 in July; Appendix E.8). For example, in January, stations SD8, SD10 and SD12 had much higher invertebrate abundances than the other three

Table 6.4
Species of megabenthic invertebrates collected in 12 trawls in the PLOO region during 2010. PA = percent abundance; FO = frequency of occurrence; MAO = mean abundance per occurrence; MAH = mean abundance per haul.

Species	PA	FO	MAO	MAH	Species	PA	FO	MAO	MAH
Lytechinus pictus	91	100	1477	1477	*Elthusa vulgaris*	<1	17	2	<1
Acanthoptilum sp	5	92	81	74	*Philine alba*	<1	8	3	<1
Strongylocentrotus fragilis	3	33	131	44	*Arctonoe pulchra*	<1	17	1	<1
Ophiura luetkenii	1	100	12	12	*Loxorhynchus grandis*	<1	17	1	<1
Pleurobranchaea californica	<1	67	7	5	*Tritonia diomedea*	<1	17	1	<1
Neosimnia barbarensis	<1	42	6	3	*Antiplanes catalinae*	<1	8	1	<1
Parastichopus californicus	<1	83	3	2	*Astropecten ornatissimus*	<1	8	1	<1
Astropecten verrilli	<1	67	3	2	*Calliostoma turbinum*	<1	8	1	<1
Luidia asthenosoma	<1	33	5	2	*Cancellaria crawfordiana*	<1	8	1	<1
Luidia foliolata	<1	50	3	1	*Dendronotus iris*	<1	8	1	<1
Philine auriformis	<1	42	3	1	*Doris montereyensis*	<1	8	1	<1
Octopus rubescens	<1	58	1	1	*Euspira draconis*	<1	8	1	<1
Sicyonia ingentis	<1	33	3	1	*Florometra serratissima*	<1	8	1	<1
Luidia armata	<1	33	2	1	*Hemisquilla californiensis*	<1	8	1	<1
Suberites latus	<1	42	1	1	*Metacrangon spinosissima*	<1	8	1	<1
Thesea sp B	<1	25	2	1	*Metridium farcimen*	<1	8	1	<1
Armina californica	<1	17	3	1	*Odontaster crassus*	<1	8	1	<1
Rossia pacifica	<1	17	3	1	*Ophiopholis bakeri*	<1	8	1	<1
Paguristes bakeri	<1	33	1	0	*Paguristes turgidus*	<1	8	1	<1
Platymera gaudichaudii	<1	25	1	0	*Platydoris macfarlandi*	<1	8	1	<1
Crangon alaskensis	<1	17	2	0	*Spatangus californicus*	<1	8	1	<1

stations due to relatively large catches of *L. pictus* (i.e., ≥1300/haul). Similarly, low diversity values (≤1.1) for the region were caused by the numerical dominance of this single species. Dominance of *L. pictus* is typical for the types of habitats encountered in the PLOO region and throughout the SCB (Allen et al. 1998).

Invertebrate species richness and abundances have varied temporally since 1991 when surveys began (Figure 6.7). For example, species richness has ranged from 3 to 29 species per year, with overall patterns of change being similar among stations. In contrast, change in total invertebrate abundance has differed greatly among trawl stations. Average annual invertebrate catches have been consistently low at northern farfield stations, while abundances at nearfield and southern farfield stations fluctuated substantially over time. As stated above, these fluctuations typically reflect changes in *L. pictus* populations, although populations of the sea pen *Acanthoptilum* sp, the sea urchin *Strongylocentrotus fragilis*, the shrimp *Sicyonia ingentis*, the sea cucumber *Parastichopus californicus*, and the sea star *Astropecten verrilli* have also varied noticeably (Figure 6.8). Low abundances of *L. pictus* and *A. verrilli* at northern farfield stations likely reflect differences in sediment composition (e.g., fine sands vs. mixed coarse/fine sediments, see Chapter 4). None of the observed variability in the trawl-caught invertebrate community can be related to the discharge of wastewater from the PLOO.

Discussion

Comparison of fish population parameters over 20 years coupled with multivariate analysis provide

Table 6.5

Summary of megabenthic invertebrate community parameters for PLOO trawl stations sampled during 2010. Data are included for species richness (number of species), abundance (number of individuals), and diversity (H'); ns = not sampled; SD = standard deviation.

Station	January	July
Species Richness		
SD7	9	16
SD8	10	14
SD10	13	17
SD12	9	17
SD13	7	15
SD14	8	11
Survey Mean	9	15
Survey SD	2	2
Abundance		
SD7	1351	2654
SD8	1116	1438
SD10	2528	2340
SD12	3447	1066
SD13	1117	966
SD14	719	820
Survey Mean	1713	1547
Survey SD	1049	770
Diversity		
SD7	0.2	0.2
SD8	0.1	0.2
SD10	0.1	0.2
SD12	0.3	0.9
SD13	0.3	1.1
SD14	0.6	1.1
Survey Mean	0.2	0.6
Survey SD	0.2	0.5

insight into spatial and temporal variability of demersal fish populations across the PLOO region. Pacific sanddabs continued to dominate fish assemblages during 2010 as they have for many years, and accounted for 42% of the total fish catch. Other characteristic, but less abundant species of fish that occurred at >75% of sites included California lizardfish, halfbanded rockfish, longspine combfish, plainfin midshipman, pink seaperch, yellowchin sculpin, Dover sole, stripetail rockfish, shortspine combfish, English sole, greenstriped rockfish, and bigmouth sole. The majority of individuals surveyed continued to be relatively small in size, and averaged less than 20 cm in length. Spatial analysis found that abundance of many fish species was greater at northern farfield stations (~8 km north of the PLOO) than at southern farfield stations (9 km south of the PLOO). The lack of significant differences between fish abundances from nearfield sites to any of the farfield sites suggests that the PLOO is not affecting demersal fish abundances. Similarly, although a significant temporal difference in fish abundances was detected, the years where changes occurred were not related to the onset of PLOO wastewater discharge, and are instead indicative of natural, large-scale oceanographic processes.

As in previous years, assemblages of megabenthic invertebrates in the region were dominated by the sea urchin *Lytechinus pictus*. Variation in overall community structure of trawl-caught invertebrates generally reflects changes in the abundance of this species, although other species such as the brittle star *Ophiura luetkenii*, the sea pen *Acanthoptilum* sp, the sea slug *Pleurobranchaea californica*, the sea cucumber *Parastichopus californicus*, the sea stars *Astropecten verrilli* and *Luidia foliolata*, and the octopus *Octopus rubescens* also contributed to some community differences.

Overall, results of the 2010 trawl surveys provide no evidence that wastewater discharged through the PLOO has affected either demersal fish or megabenthic invertebrate communities in the region. Although highly variable, no significant differences in the abundance and distribution of trawl-caught fishes were found between stations located near the outfall when compared to sites located farther away. Additionally, no patterns among invertebrate species assemblages relating to the PLOO were detectable. These results are supported by the findings of another recent assessment of these communities off San Diego (City of San Diego 2007). Significant changes in these communities appear most likely to be due to natural factors such as change in ocean water temperatures associated with large-scale oceanographic events or to the mobile nature of many of resident species. Finally, the absence of

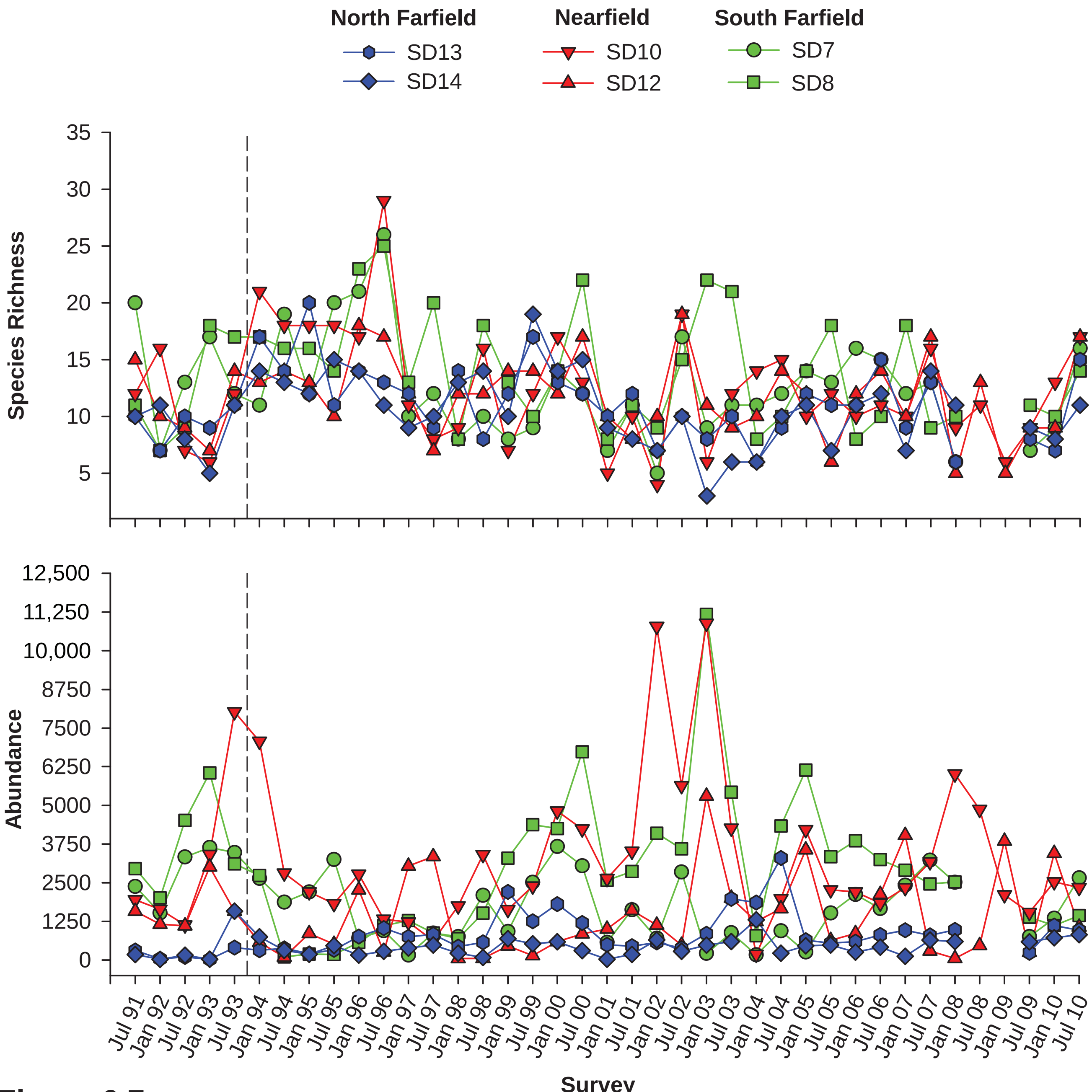

Figure 6.7

Species richness and abundance of megabenthic invertebrates collected at each trawl station between 1991 and 2010. Data are total number of species and total number of individuals per haul, respectively. Dashed line represents initiation of wastewater discharge. Only stations SD10 and SD12 were sampled during July 2008 and January 2009 due to a Bight'08 resource exchange.

disease or other physical abnormalities in local fishes suggests that their populations continue to be healthy off Point Loma.

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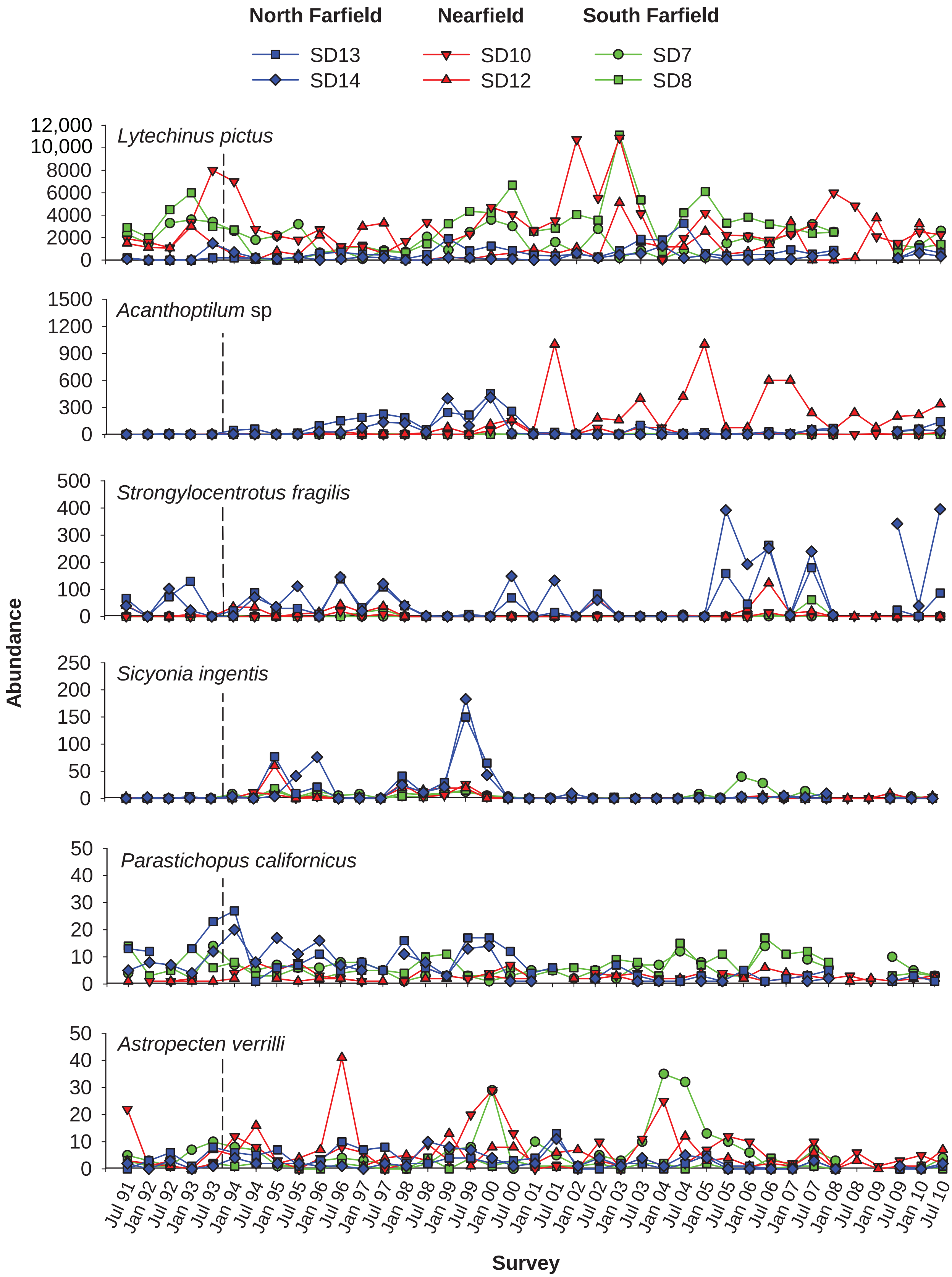

Figure 6.8

The five most abundant megabenthic species collected in the PLOO region from 1991 through 2010. Data are total number of individuals per haul. Dashed line represents initiation of wastewater discharge. Only stations SD10 and SD12 were sampled during July 2008 and January 2009 due to a Bight'08 resource exchange.

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